PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

JACKSON LAKE DAM
WHITE SULPHUR SPRINGS, MONTANA
MEAGHER COUNTY
MT 53

prepared for

HONORABLE TED SCHWINDEN
GOVERNOR, STATE OF MONTANA

RONALD JACKSON
(OWNER-OPERATOR)

prepared by

HKM ASSOCIATES
BILLINGS, MONTANA

MARCH 1981

SEATTLE DISTRICT
UNITED STATES
ARMY CORPS OF ENGINEERS

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EXECUTIVE SUMMARY

Personnel of HKM Associates, under a contract with the Montana Department of Natural Resources and Conservation (DNRC), and with representation from the DNRC and Soil Conservation Service (SCS), inspected Jackson Lake Dam on June 25, 1980. The inspection and evaluation were performed under the authority of Public Law 92-367. Jackson Lake Dam is located on North Fork Woods Gulch Creek, approximately 9 miles southwest of White Sulphur Springs, Meagher County, Montana. The dam was built in 1936 by Oakley Jackson, the father of the present owner/operator, Ronald Jackson.

FINDINGS AND EVALUATION

Jackson Lake stores runoff from a drainage basin of 5.9 square miles. The basin consists primarily of rolling prairies and the foothills of the Big Belt Mountains. Jackson Lake was built primarily as an irrigation storage facility. Incidental benefits related to the storage project are floodwater detention and sediment accumulation. Storage capacity to the spillway crest elevation is estimated to be 372 acre-feet (AF). Total estimated capacity to the first overtopping dam crest elevation (5184.1 feet, see note on page viii) is 490 AF. The dam has a hydraulic height of 32 feet. On the basis of criteria in the U.S. Army Corps of Engineers' Recommended Guidelines for Safety Inspection of Dams (Ref. 1), the project is small in size. Hanson Reservoir (storage to first overtopping elevation of 240 AF) is located on Woods Gulch Creek approximately 4 miles downstream from Jackson Lake Dam. There are no inhabitable structures located between Jackson Lake and Hanson Reservoir. However, there are a sufficient number of inhabitable structures in the flood plain downstream of Hanson Reservoir that a Jackson Lake Dam failure (and likely consequential failure of Hanson Reservoir Dam) could endanger many lives. In addition, there is farmland upstream and downstream of Hanson Reservoir, and a county road, a few private roads, and a few private utilities downstream of Hanson Reservoir that would be affected in the event of a Jackson Lake Dam breach. The downstream hazard potential is therefore high (Category 1). However, no dam breach analysis or routing of breach floods was made for the area downstream of Jackson Lake. The conclusions on probable damage are based on a brief field inspection and engineering judgment.

The guidelines recommend that the discharge and/or storage capacity of a small-size, high downstream hazard potential dam be capable of safely handling a flood of one-half Probable Maximum Flood (PMF) to a full PMF. Because of the assessed downstream risk potential (Hanson Reservoir, a small, high downstream hazard potential dam located 4 miles downstream of Jackson Lake, and at

least 3 inhabitable structures and appreciable economic loss), it is recommended the project safely handle one-half the PMF. The PMF is the flood expected from the most severe combination of meteorologic and hydrologic conditions that are reasonably possible in the region. The estimated PMF for Jackson Lake has a peak discharge of 24,720 cubic feet per second (cfs) and a total 72-hour volume of 3390 AF.

For the flood routing, the initial reservoir pool was assumed to be at the spillway crest elevation (5181 feet), and the outlet works was assumed closed. Routing of the estimated PMF for Jackson Lake showed that the project has the capacity to control a flood having ordinates approximately equal to 9.5 percent of the PMF hydrograph ordinates.

The total outlet works facility was not capable of being field-evaluated due to the pool level at the time of survey and the fact that the conduit is too small (15 inches in diameter) to allow inspection with available equipment. The corrugated steel pipe which is exposed at the outlet end is in good condition, but there is some water seeping from the pipe joints.

There is no record of any foundation investigation performed at the damsite either before or since construction. There are no project drawings available. It is not known if there is a seepage control system, and no drain outlets were observed during the field inspection. The owner is uncertain whether there is a core trench, a drain system, and/or cutoff collars along the outlet works pipe.

Some seepage was observed at the toe of the embankment along the valley floor, and in the downstream valley. No seepage was evident on the downstream face of the dam. Specific details relative to the phreatic surface through the embankment are unknown due to a limited informational base and the fact that field measurements could not be made. It is concluded, however, that the existing seepage does not pose any immediate structural stability problems.

The results of the surficial examination of Jackson Lake Dam generally indicate the embankment is stable and in reasonably good condition. There is a loss or misplacement of rock riprap on the upstream face, and minor topsoil sloughing on the downstream face. Settlement does not appear to be a problem. Some questions remain, however, relative to the embankment stability because sufficient information is not presently available to fully evaluate the dam.

A comparison of report findings with inspection guidelines shows Jackson Lake to have insufficient storage and/or discharge

capacity to safely handle the recommended spillway design flood (SDF), which is one-half PMF. The project, therefore, has an inadequate spillway that does not conform to the guidelines. The dam embankment is considered to be in reasonably good condition, however, sufficient information is not available to fully evaluate stability. Although the spillway banks in the return channel are unstable, they do not pose a threat to dam safety. Specific repair requirements and recommendations are presented below.

RECOMMENDATIONS

Immediately develop, implement, and test a downstream warning plan, and implement a more active maintenance plan. Consolidate the Jackson Lake warning plan with any developed for Hanson Reservoir. The following repairs are required on the outlet works facility: provide better access to the riser and gate controls; repair the gate operator and install a cover for the riser; repair the gate seat; inspect the total length of the outlet works, including the intake area, and perform the necessary repairs; investigate the source of seepage below the pipe at the outlet and identify potential adverse effects; and place additional rock riprap at the outlet. Perform the following repairs on the spillway: enlarge the channel section from approximately HKM Survey Station 1+60 to the vertical drop, and revegetate the side slopes where necessary. Recommended repairs on the embankment include: replacement/rearrangement of rock riprap on the upstream face, and remove the small bushes from the upstream face. Repair of an erosion gully and modification of the localized runoff system is required immediately upstream of the right abutment.

Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity. Conduct and place on file stability and seepage analyses of the dam embankment. Modify the project as studies indicate.

Conduct periodic inspections of the project at 5-year intervals by engineers experienced in dam design and construction. Include an inspection of the total length of pipe through the embankment in this program. Develop and implement a periodic maintenance plan for the dam and appurtenant structures.

Prior to performing engineering studies and remedial construction, coordinate the work with the Montana DNRC, Dam Safety Section, to insure compliance with all pertinent laws and regulations.

Mike Keene

Michael D. Keene
Professional Engineer

PERTINENT DATA SUMMARY

1. <u>General</u>

Federal ID Number	MT 53
Owner and Operator	Ronald Jackson
Purpose	Irrigation
Location	Section 34, T9N, R5E, MPM; 9 miles southwest of White Sulphur Springs, MT
County, State	Meagher County, Montana
Watershed	North Fork Woods Gulch Creek
Hazard Potential	Category 1 (High)
Size Classification	Small

2. <u>Reservoir</u>

Surface Area at Spillway Crest Elevation 5181.0 feet (see note, page viii)	36 acres
Estimated Storage to Spillway Crest Elevation 5181.0 feet	372 acre-feet
Estimated Storage to First Overtopping Dam Crest Elevation 5184.1 feet	490 acre-feet
Total Drainage Area	5.9 square miles
Reservoir Water Surface Elevation on the Day of the Inspection, or Normal Water Surface (NWS)	5181.0 feet

PERTINENT DATA SUMMARY
(Continued)

3. Spillway

Crest Elevation	5181.0 feet
Type	Unregulated earth spillway
Width at Control Point (HKM Survey Station 2+72)	12 feet
Spillway Capacity To First Overtopping Dam Crest Elevation 5184.1 feet	210 cubic feet per second

4. Outlet Works

Gate	Slidegate valve
Control	Manual operator
Conduit	150 feet (estimated) of 15-inch diameter corrugated steel pipe
Capacity	
To Spillway Crest Elevation 5181.0 feet	14 cubic feet per second
To First Overtopping Dam Crest Elevation 5184.1 feet	14 cubic feet per second

5. Dam

Type	Zoned earth fill
Structural Height (estimated)	32 feet
Hydraulic Height	32 feet
Existing First Overtopping Dam Crest Elevation	5184.1 feet
Total Crest Length	391 feet
Existing Dam Crest Width	Variable 20-30 feet

PERTINENT DATA SUMMARY
(Continued)

Upstream Slope	1V on 2H above NWS
Downstream Slope	1V on 1.8H above berm 1V on 1.6H below berm

Note: The normal water surface (NWS) is assumed to be at elevation 5181 feet NGVD based on the water surface shown on the Hanson Reservoir Quadrangle Map, 1971. Elevations will not be shown as "NGVD" since it is not known if the water surface shown on the map is exactly the NWS.

CHAPTER 1
BACKGROUND

1.1 INTRODUCTION

1.1.1 Authority

This report summarizes the Phase I inspection and evaluation of Jackson Lake Dam. The project is owned and operated by Ronald Jackson.

The National Dam Inspection Act, Public Law 92-367 dated August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to conduct safety inspections of non-federal dams throughout the United States. Pursuant to that authority, the Chief of Engineers issued "Recommended Guidelines for Safety Inspection of Dams" in Appendix D, Volume 1 of the U.S. Army Corps of Engineers' Report to the United States Congress on "National Program of Inspection of Dams" in May 1975.

The recommended guidelines were prepared with the help of engineers and scientists highly experienced in dam safety from many federal and state agencies, professional engineering organizations and private engineering consulting firms. Consequently, the evaluation criteria presented in the guidelines represent the comprehensive concensus of the engineering community.

Where necessary, the guidelines recommend a two-phased study procedure for investigating and evaluating existing dam conditions so deficiencies and hazardous conditions can be readily identified and corrected. The Phase I study is:

(1) a limited investigation to assess the general safety condition of the dam

(2) based upon an evaluation of the available data and a visual inspection

(3) performed to determine if any needed emergency measures and/or if additional studies, investigations and analyses are necessary or warranted

(4) not intended to include extensive explorations, analyses, or to provide detailed alternative correction recommendations.

The Phase II investigation includes all additional studies necessary to evaluate the safety of the dam. Included in Phase

II, as required, should be additional visual inspections, measurements, foundation exploration and testing, material testing, hydraulic and hydrologic analyses and structural stability analyses.

The authority for the Corps of Engineers to participate in the inspection of non-federally owned dams is limited to Phase I investigations with the exception of situations of extreme emergency. In these cases the Corps may proceed with Phase II studies but only to the extent needed to answer serious questions relating to dam safety that cannot be answered otherwise. The two phases of investigations outlined above are intended only to evaluate project safety and do not encompass in scope the engineering required to perform design or corrective modification work. Recommendations contained in this report may be for either Phase II safety analyses or detailed design study for corrective action.

The responsibility for implementation of these Phase I recommendations rests with the State of Montana, Department of Natural Resources and Conservation. The operator is urged to contact the Montana DNRC prior to taking any action on report recommendations. It should be noted that nothing contained in the National Dam Inspection Act, and no action or failure to act under this Act, shall be construed (1) to create liability in the United States or its officers or employees for the recovery of damage caused by such action or failure to act or (2) to relieve an owner or operator of a dam of the legal duties, obligations, or liabilities incident to the ownership or operation of the dam.

The investigation process allows for report review by: the Montana DNRC; the Soil Conservation Service (SCS); and Ronald Jackson (owner and operator). Review comments are considered before final publication of the Phase I Inspection Report. The written comments received are enclosed in Appendix E.

1.1.2 Purpose and Inspection

The findings and recommendations in this report were based on visual inspection of the project, minimal field survey measurements, and review of available design and operation data. The purpose of the inspection is to make a general assessment as to the structural integrity and operational adequacy of the dam embankment and its appurtenant structures. Inspection procedures and criteria were those established by the Recommended Guidelines for Safety Inspection of Dams (Ref. 1).

The visual inspection of Jackson Lake Dam was made on June 25, 1980. HKM Associates personnel who attended the field inspection and contributed to this report were:

Dan Dyer, Geotechnical Engineer
Gary Elwell, Hydraulics/Hydrology
Mike Keene, Hydraulics/Hydrology, Team Leader

Other HKM personnel contributing to the report but not attending the field inspection were:

Dale R. Cunnington, Structural Engineer
William Hansen, Hydraulics/Hydrology
Dan Nebel, Geology

Other personnel present during the June 25, 1980 inspection included:

Glen McDonald, Supervisor, Montana DNRC, Dam Safety Section
Larry Tegg, Dam Safety Engineer, Montana DNRC, Dam Safety Section
Dave Jones, SCS
Glenn Malmquist, SCS
Ronald Jackson, Owner
Gilbert Jackson, Brother of Owner and Water User

1.2 DESCRIPTION

1.2.1 General

Jackson Lake Dam is an earth fill dam located in the NE 1/4 of Section 34, T9N, R5E, M.P.M., Meagher County, Montana (Appendix A and Ref. 2 and 3). Ronald Jackson owns and operates the project.

The storage project forms an irrigation facility within the Missouri River Basin by containing the water of North Fork Woods Gulch Creek and tributaries. Jackson Lake water is returned to North Fork Woods Gulch Creek. Water then travels approximately 4 miles before reaching Hanson Reservoir Dam, an additional 0.9 mile to a small county road embankment and then another 0.5 mile before joining the Smith River (Appendix A and Ref. 2). The nearest downstream community is Fort Logan, Montana, which is located on the west bank of the Smith River approximately 13 miles north-northwest of the dam. In terms of a stream channel distance, Fort Logan is located 19 miles downstream of the dam. There are several homes located in the floodplain of Woods Gulch Creek and the Smith River.

Jackson Lake Dam has a hydraulic height of 32 feet and impounds 490 AF at the first overtopping dam crest elevation (elevation

5184.1 feet, see note page viii). Based on a visual reconnaissance and engineering judgment, at least three residences, as well as county and private roads, private utilities, Hanson Reservoir Dam, and agricultural land will be affected by a sudden breach of the dam. Of particular importance would be Hanson Reservoir Dam located about 4 miles downstream of the dam. It is assumed that both Hanson Reservoir Dam and the small county road embankment will breach in the event of a Jackson Lake Dam breach. On the basis of this information and in accordance with the Recommended Guidelines (Ref. 1), the project is classified small in size and the downstream hazard potential is high (Category 1).

Jackson Lake Dam was constructed to provide storage and regulation in support of irrigation practices. Incidental benefits are provided for floodwater detention and sediment accumulation. Storage to the normal pool level, or the spillway crest (elevation 5181.0 feet) is 372 AF (Ref. 2 and Exhibit D1 of Appendix D). An additional 118 AF are available for flood surcharge storage between the spillway crest and the first overtopping dam crest elevation (elevation 5184.1 feet).

Jackson Lake Dam has a total upstream contributory drainage area of 5.9 square miles. The Jackson Lake watershed is characterized by both foothill and rolling prairies. Elevations in the basin range from 7980 feet NGVD to about 5200 feet NGVD at the reservoir (Ref. 3). The reservoir is located in open, generally rolling terrain (Photo 1 of Appendix B).

1.2.2 Regional Geology

Jackson Lake Dam is situated on the eastern edge of the Big Belt Mountains, a structurally complex region between the Big Belt uplift immediately to the west, the Little Belt uplift to the east and the Castle Mountain dome to the south and east. The dam is situated in a topography of high rounded hills. The strata shows a uniform east-southeast dip of about 30 degrees with the Greyson Shale Formation (pre-Cambrian) forming the surface of the area. Faulting is extensive in the area with major thrust faults extending the length of the Smith River valley east of White Sulphur Springs and numerous normal and reverse faults bordering the Big Belt uplift immediately west of the damsite. There is, however, no evidence of recent fault movement (Ref. 4).

1.2.3 Seismicity

Jackson Lake Dam is in a moderately active to active seismic zone with the majority of the region's seismic events occurring in the southwestern Montana-Yellowstone Park area. Since 1925, Montana has experienced five shocks that reached intensity VIII or greater (Modified Mercalli Scale).

The closest epicenter of an intensity VIII or greater occurred in the Helena, Montana area which is approximately 40 miles west of the damsite. Numerous other shocks of intensity IV or greater have been reported within a 100-mile radius of the site (as of January 1974). The site is located in zone 3 of the Seismic Zone Map of Contiguous States, and it can be assumed that a major earthquake may occur within the life of the structure (Ref. 1, 5). Although the Zone Map is based on a known distribution of damaging earthquakes, it does not necessarily reflect accurate or adequate seismic design parameters for this site.

1.2.4 Site Geology

No drill hole or site reconnaissance data for the dam is available. This section of the report is developed from regional geologic information and personal knowledge of the area.

The reservoir basin is composed of moderately metamorphosed shale and argillite of pre-Cambrian age. The valley section consists of thin alluvial deposits of sand, gravel, and clay overlying weathered shale. Based on field inspection, sediment does not appear to present a problem.

The outlet works and plunge pool are located in alluvium which is protected by minimal angular riprap.

Erosion of soil and soft shale materials in the spillway return channel was noted during the field inspection. This can be expected to continue unless some protection is provided. The spillway approach channel is composed of highly erodible materials.

1.2.5 Design and Construction History

Jackson Lake Dam was built in 1936 for Oakley Jackson to store and regulate runoff, the sole purpose of which was to enhance the irrigated agriculture practice downstream. The owner reports that technical design assistance for the 1936 construction was provided by the Soil Conservation Service. Construction contractors on the original structure were Schye and Sullivan. It is reported that the original project was a cost-share venture as it had qualified as a "government action project". The current owner is listed as Ronald Jackson, who is a son of the original builder/owner.

Several significant improvements have been made to Jackson Lake Dam since 1936. The first improvement came in 1946 when a headgate was placed on the upstream end of the low-level outlet pipe. Previous to placing this headgate, the 15-inch diameter corrugated steel pipe (CSP) operated completely uncontrolled.

In 1950, the dam was raised approximately 10 feet to increase the storage capability of the project. The old spillway was abandoned and a new earthen spillway was constructed at or near the left abutment area. The 1950 construction was performed by Lowell Schendel, and it is again reported as receiving cost support from the federal government.

Jackson Lake Dam was again raised by about 10 feet in 1968. It is reported that shale material was placed over the top of the old dam. The embankment material was supposedly placed such that there are alternating layers of shale and clay. A layer of clay was placed on the upstream face, followed by a protective layer of rock riprap. Also completed during the 1968 program was the placing of approximate 32-foot extensions on the upstream and downstream ends of the 15-inch CSP low-level outlet pipe, and about 32 feet of 36-inch CSP riser to contain the gate and gate controls. The spillway was moved further north to accommodate the enlarged embankment. The spillway constructed in 1950 was abandoned. Lowell Schendel also performed the 1968 work.

Excessive seepage was occurring subsequent to the 1968 work, and in about 1978 the upstream slope was blanketed with a layer of clay about 12 feet thick and covered with rock riprap. It is reported that the seepage decreased substantially following the blanket placement.

Severe erosion was reported to be occurring at the right abutment on the upstream side, primarily due to wave action. In 1979, shale material was first placed to fill the cavity, then rock riprap was placed over the shale for improved protection.

There were no design calculations, drawings, or quality control testing results available for review. It could not be verified that quality control testing was performed during any of the above improvements. Except for the technical design assistance provided by the SCS on the original structure, the nature and extent of technical assistance on the project is unknown.

CHAPTER 2
INSPECTION AND RECORDS EVALUATION

2.1 HYDRAULICS AND STRUCTURES

2.1.1 Spillway

Jackson Lake Dam has an unregulated, earthen spillway located on the left (north) abutment. The spillway maintains a trapezoidal shape with a variable base width and approximate side slopes of 1V on 2H. The trapezoidal shape transitions to a deeply eroded ravine about 360 feet downstream of the spillway inlet. Particular features include an inlet, a crest, a control point, a vertical drop, and a return channel. There is no stilling basin (Photos 2 and 3 of Appendix B and Exhibits C1 and C4).

The spillway inlet section has a contributory width of approximtely 85 feet with bank heights of 2 to 3 feet. Sixty feet into the spillway channel the base width has narrowed to 20 feet with bank heights of approximately 4 feet. The spillway crest is located at Station 1+54 (HKM Survey dated 6/25/80) and has an elevation of 5181.0 feet (see note on page viii). In the vicinity of the crest, the channel base width has reduced to 18 feet and the bank heights have increased to about 10 feet. About 100 feet further along the channel the base width is 12 feet with bank heights of approximately 15 feet. The spillway control point is located at HKM Survey Station 2+72, or 272 feet downstream of the inlet (the control point was identified by performing hydraulic analyses for a range of spillway discharges). At a distance of about 360 feet downstream of the spillway inlet, and immediately upstream of the vertical drop, the base width has narrowed to 6 feet and the bank heights have decreased to about 10 feet. After the vertical drop, the flows are contained within a deeply eroded ravine. Water reenters North Fork Woods Gulch Creek about 400 feet downstream of the dam. Energy dissipation is provided primarily by cascading water through the ravine.

The owner indicates the spillway operates 9 out of 10 years. Highwater marks indicate a maximum pool level of approximately 12 inches above the normal water surface.

The spillway banks upstream of the vertical drop appear stable, but are composed of highly erodible materials, with little vegetative cover (Photo 2 of Exhibit B). The spillway is located approximately 400 feet from the left dam abutment, therefore erosion in the spillway channel should not present a dam safety problem. Vertical walls and bank sloughing are present downstream of the vertical drop, but sloughing should not be sufficient to reduce flow capacity in the spillway channel and

create a safety concern for the dam (Photo 3 of Exhibit B). In general, the spillway is in relatively good condition and should not pose a serious threat to the dam embankment.

Spillway rating information was not available. Therefore, new hydraulic rating information was developed using the U.S. Army Corps of Engineers computer program HEC-2 (Ref. 14). Calculations were performed assuming spillway flows pass through critical depth at the vertical drop, a Manning's "n" of 0.03, and the return channel slope is steep enough to prevent backwater effects. Form losses were accounted for from the vertical drop to the reservoir pool. It was found that the control point for spillway flows ranging from 25 cubic feet per second (cfs) to a maximum capacity of 210 cfs at the first overtopping dam crest elevation (5184.1 feet), is located about 272 feet downstream from the inlet and 88 feet upstream of the vertical drop. Final spillway rating data is presented in Exhibits D2 and D3 of Appendix D.

2.1.2 Outlet Works

The outlet works for Jackson Lake Dam is located about 130 feet from the right (south) abutment contact and aligned approximately perpendicular to the dam crest. Based on field investigation and information available from the owner, the pipe is a 15-inch corrugated steel pipe (CSP), flow regulation is provided by a slidegate valve (installed 1946) in a wet well riser (added in 1968) on the upstream face of the dam, energy dissipation is provided by a plunge pool with some rock along the bottom and sides, pipe extensions were added on both the upstream and downstream end of the pipe (added in 1968), the pipe invert at the outlet is 5182.8 feet (see note on page viii), and asphaltic coating and cutoff collars were probably not used.

It was not possible to inspect the inlet structure or the total length of the outlet pipe due to the pool level at the time of the inspection and the size of the outlet pipe. A visual inspection was made of the exposed section of the wet well riser, the exposed outlet pipe, and the plunge pool. The riser is tilted slightly towards the embankment, but this does not appear to present a problem. There is seepage water exiting along the bottom of the conduit in three or four places (Photo 4 of Appendix B). Seepage at each spot is estimated to be less than 2 gallons per minute (gpm). It could not be determined whether this water was just running along the outside of the pipe due to embankment seepage or leaking out of a pipe joint or seam. In any case, the seepage/leakage is not considered serious at this time. Asphaltic coating was not provided on the exposed section of pipe. A small amount of water was leaking from a joint in the exposed, riveted section of outlet pipe about 24 inches upstream of the pipe outlet (Photo 5 of Appendix B).

According to the owner the gate was closed as much as possible, yet water was exiting the pipe at a flow depth of approximately 2-1/2 inches. The gate was opened a couple of inches to test the operational capability of the gate and observe the downstream effects. The gate was only opened a small amount because of irrigation practice and possible damage to the outlet area. The owner indicates that the gate has recently been operated through the complete range of travel. The wheel on the gate stem has been removed to prevent unauthorized operation, therefore, the gate is opened by a mechanical hoist and closed with a hammer. An operational constraint exists because the wet well is separated from the dam embankment by at least 10 feet of water. During the inspection it was necessary to place a ladder between the dam embankment and the wet well for access to the gate controls. This same operation technique would need to be employed during high pool levels. Rocks are commonly thrown in the wet well which could also hamper gate operation.

New outlet works rating information was developed since no hydraulic information was available. Outlet works capacity with the reservoir at the spillway crest (elevation 5181.0 feet) is estimated to be approximately 14 cfs, and 14 cfs to the first overtopping dam crest elevation (5184.1 feet). Estimates are based on assumptions that the operating gate is in the fully open position, full conduit flow exists throughout the entire length, and that a representative value for Manning's "n" is 0.025. Final outlet works rating data is summarized in Exhibits D2 and D3 of Appendix D.

2.1.3 Freeboard

The guidelines' (Ref. 1) recommended spillway design flood (SDF) for a small, high hazard dam falls in a range of 50 percent of the probable maximum flood (PMF) to the full PMF. Based on downstream hazard, 50 percent of the PMF was chosen. Flood routing (Section 2.2.3) indicates the dam overtops during the 50 percent PMF, and therefore, no freeboard exists for such conditions. The vertical distance from the spillway crest (elevation 5181.0 feet, see note on page viii) to the first overtopping dam crest elevation (5184.1 feet) is 3.1 feet. The vertical distance between the reservoir pool and the first overtopping at the time of the June 1980 field inspection was 3.1 feet.

Jackson Lake is basically oriented in an east-west direction, with the dam on the east side. The prevailing wind for this region is generally identified as being westerly (Ref. 6, 7). The reservoir location and orientation can be observed in Appendix A. The effective fetch length is calculated to be 0.4 mile. Hence, a minimum freeboard allowance should be 3 feet

(Ref. 8). There is adequate protection for wave runup (3.1 feet) when the pool is at the NWS, but not at higher pool levels.

2.2 HYDROLOGY

2.2.1 Physiography and Climatology

The 5.9-square mile catchment area above Jackson Lake is irregular in shape, with the length dimension being considerably greater than width (Appendix A). In particular, the drainage area is approximately 5 miles long and only 1.2 miles wide. The topography includes rolling prairies and foothills. The immediate vicinity of the reservoir can primarily be characterized as rolling prairie drainage. The watershed rises from the reservoir in a southwesterly direction by gradual slopes and bench lands to the foothills of the Big Belt Mountains.

Soils in the lower portion of the drainage area are primarily Hanson Stony Loam with mountain forested soils in the upper elevations (Ref. 9).

The regional climate is classified as distinctly continental, and characterized by abundant sunshine, low relative humidity, moderate rainfall, and wide daily and seasonal variations in temperature. However, the regional climate does not have the extreme variable pattern common to the more mountainous western sections in Montana. In general, the valleys are relatively dry during the colder months and wet during the late spring and early summer. The wettest part of the year in the mountains is generally from midwinter to early spring. It is not uncommon for the region to experience winter warming spells with associated thawing temperatures. Precipitation near the Jackson Lake watershed ranges from about 17.5 inches at White Sulphur Springs (9 miles northeast of the dam) to amounts in excess of 30 inches in the foothills of the Big Belt Mountains. The average annual temperature at White Sulphur Springs is approximately 41 degrees Fahrenheit. Winters are typically cold, with January being the coldest month. The monthly average temperature for January at White Sulphur Springs is about 20 degrees Fahrenheit. During the summer, July is typically the warmest month with an average temperature of about 64 degrees Fahrenheit. It is assumed that saturated, unfrozen ground conditions would be present during a typical late spring, early summer rainfall/runoff event (Ref. 6, 7).

No streamflow measurements on North Fork Woods Gulch Creek or pool level records on Jackson Lake are available.

2.2.2 Estimated Probable Maximum Flood (PMF)

The probable maximum precipitation (PMP) and the estimated probable maximum flood were developed for the Jackson Lake drainage basin. The ratio of the reservoir area to the nonreservoir area is less than 1 percent; therefore, the two areas were not separated for the purpose of this analysis.

The PMF is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the study region.

Jackson Lake is located west of the 105th meridian and east of the continental divide, hence PMP values were calculated using procedures associated with the National Weather Service Interim Method (Ref. 10). The Interim Method provides PMP values for durations of 6 to 72 hours, with PMP values for 1 to 5 hours obtained by multiplying the 6-hour PMP value by percentages supplied by the Corps of Engineers, Seattle District. The PMP 6-hour, 12-hour, 24-hour, 48-hour, and 72-hour values are 9.6 inches, 12.0 inches, 14.3 inches, 16.4 inches and 17.9 inches, respectively. The 6-hour PMP value of 9.6 inches was multiplied by 67 percent, 78 percent, 85 percent, 91 percent, and 95 percent to obtain PMP values of 6.4 inches, 7.5 inches, 8.2 inches, 8.7 inches and 9.1 inches for durations of 1-hour, 2-hours, 3-hours, 4-hours, and 5-hours, respectively.

The 6-hour increments for the total 72-hour storm were arranged in a critical distribution using criteria presented in the National Weather Service's Hydrometeorological Report No. 43 (Ref. 11). In particular, the 6-hour rainfall increments were arranged according to pattern "e". Further subdivision of the calculated rainfall increments was required to provide compatibility with the duration of the unit hydrograph. A 10-minute unit hydrograph was chosen for Jackson Lake using criteria presented in the SCS Hydrology Handbook (Ref. 12). The unit hydrograph was developed for the Jackson Lake basin using the SCS method and the U.S. Army Corps of Engineers' computer program HEC-1 (Ref. 12, 13). The PMP storm was plotted in the form of a depth-duration curve for convenience in selecting incremental rainfall values. The peak 10-minute PMP values, within the time base of the unit hydrograph, were ordered according to the reverse pattern of the unit hydrograph ordinates.

Rainfall losses were assumed equal to the minimum soil retention rate of 0.15 inches/hour for type B soils due to an assumed saturated ground condition.

The runoff condition, or PMF, resulting from a PMP storm was estimated using the PMP values and the unit hydrograph approach. The resultant PMF has a peak flow of 24,720 cfs and a 72-hour volume of 3390 AF.

2.2.3 Flood Routing

The PMF resulting from the PMP rainfall/runoff event was routed through Jackson Lake using the computer program HEC-1 (Ref. 13). Runoff from an antecedent storm was not specifically considered; however, it appears reasonable to assume the initial reservoir level prior to routing the PMF is at the spillway crest (elevation 5181.0 feet, see note page viii). The support rationale for this assumption is that Jackson Lake characteristically has a small reservoir pool and is not capable of totally absorbing rather severe flood events. Drawdown of the reservoir pool can be accomplished with the 15-inch outlet conduit. However, it is not likely that the project would be operated in this manner unless it was an emergency measure. The water users would prefer to store as much water as possible in preparation for the irrigation season. High discharge through the outlet works may cause damage in the outlet plunge pool and downstream channel. This damage would probably remain localized and not threaten the dam embankment. In summary, the "sense of emergency" is not likely to be realized by the project operator to the extent storage water and downstream conditions would be sacrificed in anticipation of the PMF event.

Reservoir elevation-area-capacity data is not available. New data was developed based on information obtained from the Hanson Reservoir and Alkali Lake Quad Maps (Ref. 2) and is provided in Exhibit D1 of Appendix D. Jackson Lake Dam discharge rating data is shown in Exhibits D2 and D3 of Appendix D. Flow through the outlet works was not included in the flood routing because the gate would probably be closed during a typical late spring, early summer flood event.

For the purposes of flood routing and according to Phase I inspection criteria, the dam crest elevation is defined as the minimum elevation to which the reservoir must rise before overtopping the dam. This criteria assumes overtopping and failure of embankment-type dams to be coincidental. Based upon the dam crest profile survey dated June 25, 1980 (Exhibit C3 of Appendix C), the existing low-point dam crest elevation is 5184.1 feet.

Flood routing showed that the dam would first overtop during the PMF when approximately 9.5 percent of the total PMF volume enters the reservoir. Routings were made of lesser hypothetical floods than the PMF to determine the magnitude of floods the dam can contain. The hypothetical hydrographs are obtained by applying percentages to the PMF ordinates. A flood with a hydrograph having ordinates corresponding to 9.5 percent PMF hydrograph ordinates is just controlled by the project. Larger floods would overtop the dam.

2.3 GEOTECHNICAL EVALUATION

The geotechnical evaluation of Jackson Lake Dam included a field investigation and a search and review of project data. The field inspection consisted of photo documentation, a dam crest profile survey, slope stability observations of the dam embankment, seepage observations, and measurements of the slope angles. Inspection photos are included in Appendix B, field drawings of the dam plan and cross section are included in Exhibits C1 and C2 of Appendix C, and the crest profile survey is shown in Exhibit C3. Results of the slope angle measurements are provided in Exhibit C1.

2.3.1 Dam Embankment

Jackson Lake Dam is an earth fill structure which was originally constructed in 1936 and remodeled three times with the latest work in 1978. A description of this remodeling is presented in Section 1.2.5. The dam has an estimated structural height above the deepest point on the foundation surface of 32 feet and a total crest length of 391 feet. The dam crest width varies from 20 to 30 feet (Photo No. 6). Construction drawings of the embankment are not available.

Construction of the embankment was described by Mr. Ronald Jackson, owner of the dam. A drawing prepared in the field and supported by the owner's description is provided in Exhibit C2 of Appendix C. Details provided by the owner indicate the embankment cross section consists of four zones, which are differentiated partly by material types and partly by construction sequence. The lower central zone was constructed in 1936 and raised in 1950. We understand this material is predominantly on-site sandy clay and residual shale soils. The material appears to be relatively permeable as considerable through-the-dam seepage has been observed by the operator in the past.

The upper central and downstream zone is a shale clay mixture constructed in 1968. The owner explained that the zone was constructed by placing alternate layers of shale and on-site clay in lifts, then mixing them in-place.

A 12-foot thick layer of clay was placed on the upstream face in 1978. Evidently this material is relatively impervious as it appears to control through-the-dam seepage. There is also a layer of riprap placed on the upstream face of the embankment. No soils compaction was performed during construction other than that which is a result of the earth moving equipment traffic.

A thick cover of riprap has been placed at the contact of the embankment with the right abutment on the upstream face to

prevent erosion due to wave action and surface runoff. A detailed description of these materials is not available in the design files.

Vegetation on the downstream dam embankment consists of grass, weeds, and bushes. The same vegetation also appears on the upstream face, but only on the left side. Rodent holes and cattle traffic are evident on the downstream face, but they do not appear to create a safety problem at this time. A small amount of debris has collected on the upstream face of the dam.

It is not known if there is a core trench under the embankment.

Embankment Settlement

A dam crest profile was surveyed during the field investigation (Exhibit C3 of Appendix C). The survey shows that the maximum differential elevation along the dam crest centerline is about 1.1 feet. Some fill has been placed on the abutments at elevations as high as 3.4 feet above the low point on the crest. It appears the dam was designed without camber, or it has settled out. The amount of settlement which it has assumed cannot be determined. In summary, the settlement to date has not caused significant structural damage. Because the dam has aged nearly 12 years since the last crest raising, additional significant amounts of settlement are not anticipated.

2.3.2 Foundation Conditions and Seepage Control

There is no record of any foundation investigation performed at the damsite either before or since construction. No soils information is known except that which was observed at the surface during the field inspection. The dam appears to be founded on shallow alluvial deposits of clay, sand, and gravel overlying weathered shale. The abutments are highly fractured deposits of shale and argillite bedrock (Photo No. 1).

It is not known if there is a seepage control system. No drain outlets were observed during the field inspection. The owner is uncertain whether there is a core trench or drain system and cutoff collars on the pipe.

It is understood that prior to the construction of the existing upstream clay blanket (1978 construction work) through-the-dam seepage was evident. It is reported that the seepage decreased substantially following the blanket placement.

Presently, there is seepage surfacing at the toe of the embankment along the valley floor (Photo No. 7), and in the valley downstream. There is no seepage evident on the downstream face of the dam. The existing seepage does not seem to pose any immediate problems to the stability of the embankment structure.

2.3.3 Stability

Embankment

The slope angles measured during the field investigation are shown in Exhibit C1 of Appendix C. These angles were measured with an Abney level and should be considered approximate.

Except for some low, near-vertical erosional cuts on the upstream slope and sloughing of the topsoil on the downstream slope (see Erosion, this section), there is no outward sign of instability. However, there is no stability analysis data available to evaluate the slope design, and the phreatic surface in the embankment and the source of seepage at the toe is unknown. Available information suggests that soils strength tests were not performed and stability calculations were not made.

Small irregularities are evident on the downstream face at several locations where topsoil has sloughed. The depth of the sloughed material is estimated to be very shallow. This condition is not considered dangerous at present but deserves monitoring.

Spillway

Slope angles were also measured in the spillway cut and are shown in Exhibit C1. This construction cut appears to be stable except for some surface soil sloughing (Photo No. 2). Below the construction cut the return channel has eroded into the natural soil producing vertical banks to heights of 6 feet (Photo No. 3). Frequently, these vertical banks slough into the channel. However, these unstable cuts do not pose a safety problem to the dam because sloughing would not be sufficient to severely obstruct the spillway.

Erosion

Erosion was observed at several locations. Without corrective measures, these points of erosion may develop into stability problems.

At isolated locations on the upstream face of the embankment, wave action has eroded the embankment to form low vertical cuts leaving the slope exposed and oversteepened.

The erosion in the spillway return channel is significant in terms of soil loss. During the spring when the spillway is operating consistently, erosion progresses very rapidly.

An erosion channel approximately 1-1/2 feet deep by 3 feet wide is located just upstream from the right abutment (Photo No. 8).

The material exposed is a weathered shale which has a tendency to slake when wet and is contributing to pool sedimentation. This area was apparently stripped during construction and never revegetated.

The reservoir shorelines are considered to be in stable condition as no major slides or scarpments were observed.

2.3.4 Rock Riprap

Rock riprap has been placed on the upstream face of the dam. This rock is a metamorphosed sandstone (Photo No. 9). Slight weathering is evidenced by the rounding of the edges and the decrease in size of the stone. There is insufficient riprap at isolated locations on the upstream face. The riprap has occasionally slipped down the embankment face due to erosion and wave action (Photo No. 10). The riprap quality appears to be adequate at this time, but should be monitored annually.

2.4 PROJECT OPERATIONS AND MAINTENANCE

Jackson Lake Dam is owned and operated by Ronald Jackson. The project was built as an irrigation storage facility. There is no formal operation plan, and operation records are not kept. Storage and releases from the reservoir are generally dictated by seasonal factors. Commonly the pool is lowered in the fall of the year to minimize winter ice damage to the low-level outlet pipe and riser. The late-spring and early-summer runoff is stored to the maximum level possible to accommodate irrigation water requirements which occur during the summer and early fall months.

At this particular time, gate operation for the low-level outlet is quite cumbersome. A sledge hammer is required for closure and a mechanical hoist arrangement is required for opening. This operation is purposeful in that the operator wanted to eliminate unauthorized operation of the gate. The only maintenance required relative to the operating gate is that about every 3 or 4 years rocks which people have tossed into the riser have to be removed.

The spillway is an unregulated facility. The owner/operator indicates that the spillway flows on the average of 9 out of 10 years. No maintenance has been performed on the spillway since its construction in 1968.

Because of the dam and reservoir orientation and consequent damaging wave action, periodic maintenance has been required on the upstream face of the dam. The last major repair was made in

1979 at the right abutment. The present dam owner indicated that they are planning to do more rock riprap work on the upstream face in affected areas.

Regular, organized inspections of Jackson Lake Dam have not historically been performed, and inspection records have not been kept. The project is inspected on an incidental basis, however, in that the owner/operator is commonly in the vicinity operating the control gate and/or farming the land. A visitation to the site is required at least a couple times a month during the irrigation season. The owner/operator lives close to the project and claims site access is adequate to allow visitation during a large storm event. However, one has to travel a couple miles on unimproved gravel roads for the site access. Hence, it appears the site is accessible during a large storm, but with some difficulty.

There is no formal warning plan of action in the event of dam distress. There are no residences between Jackson Lake and Hanson Reservoir, but there are several downstream of Hanson Reservoir. Though not part of a formal plan, the owner indicates that the downstream residences would be alerted by radios, phone, or door-to-door communication.

CHAPTER 3
FINDINGS AND RECOMMENDATIONS

3.1 FINDINGS

Visual inspection of the dam, supplemented by analysis of the project in accordance with the guidelines (Ref. 1) and the contract performance standards, resulted in the following findings.

3.1.1 Size, Hazard Classification and Safety Evaluation

In accordance with the inspection guidelines (Ref. 1), Jackson Lake Dam is classified small in size and, based on our visual inspection and judgment, it has a high downstream hazard potential. Therefore, the guidelines' recommended spillway design flood (SDF) for this project is in a range of 50 to 100 percent of the PMF. Based on the limited number of inhabitable structures and appreciable economic loss, we recommend the spillway design flood be 50 percent of the PMF. The project can safely handle a flood having 9.5 percent of the PMF ordinates without overtopping and causing the dam to fail which, in our judgment, could seriously jeopardize life and property downstream. Based on reconnaissance level investigations, the project has an inadequate spillway that does not conform to the guidelines (Ref. 1). The dam embankment is considered to be in reasonably good condition, however sufficient information is not available to fully evaluate the stability. The spillway banks in the return channel are unstable, but do not pose a threat to dam safety.

3.1.2 Spillway

The earth spillway system was designed to accommodate a relatively small flood event compared to current standards. Relative to hydraulic performance, the spillway appears to have performed adequately in the past. There are erodible materials throughout the spillway channel, and unstable banks in the return channel are evident. However, it is assumed that the soil erodibility and instability will not substantially reduce spillway capacity and/or pose a threat to the dam embankment because of the separation distance between the dam and spillway. Maximum spillway capacity, assuming the reservoir pool is at the first overtopping dam crest elevation (5184.1 feet, see note on page viii) is approximately 210 cfs. The flood water storage capacity between the spillway crest (5181.0 feet) and the first overtopping dam crest elevation amounts to 118 AF. In comparison, the PMF for the 5.9 square-mile drainage area is estimated to have a total 72-hour runoff volume of about 3390 AF. Based on flood routing, the combination of reservoir storage

and spillway discharge capability is inadequate to prevent overtopping of the dam during the SDF.

3.1.3 Outlet Works

It was not possible to inspect the intake structure and pipe throughout its total length because of the pool level at the time of the inspection and the small pipe diameter. The exposed portion of the outlet works was in relatively good condition. The exposed corrugated metal was in good structural condition, although water is leaking through a joint about 24 inches from the end of the pipe. Seepage was evident at the outlet along the bottom of the pipe in three or four places. However, it was not possible to determine the seepage source. It was not possible to obtain a complete seal of the operating gate and operation was cumbersome due to opening the gate by mechanical hoist and closing with a hammer. Reaching the gate stem was somewhat difficult in that the wet well riser, which contains the gate stem, was located at least 10 feet away from the dam crest. The owner/operator currently uses a ladder or similar device to span the water between the dam embankment and wet well. This same cumbersome technique would be required during high pool levels.

3.1.4 Dam

Except for the loss of some riprap on the upstream face and a minor amount of topsoil sloughing on the downstream face, the Jackson Lake Dam embankment appears to be stable and in reasonably good condition. Some questions exist as to the embankment stability because insufficient information is presently available to fully evaluate the dam. Settlement does not appear to be a problem. Seepage was observed at the toe of the embankment and in the downstream valley, but is not considered serious at this time. The phreatic surface through the dam is unknown.

3.1.5 Operation and Maintenance

There are no formal operation plans or maintenance programs, and there are no regular, organized inspections. Project operation is performed according to seasonal requirements. Major repairs and maintenance items have generally been performed by the owner when necessary. Jackson Lake Dam is visited regularly throughout the irrigation season by the owner/operator, and only occasionally during other periods. However, the owner/operator feels their incidental inspections and residency are adequate to identify a distress condition. There is no formal warning plan of action in the event of dam distress.

3.2 RECOMMENDATIONS

The investigation findings require a high priority be given to the following recommendations:

(1) Immediately develop, implement, and periodically test an emergency warning plan for use in the event of dam distress. The warning plan for Jackson Lake should be consolidated with any plan developed for Hanson Reservoir.

(2) Perform the following repairs on the outlet works facility: provide better access to the riser which houses the gate controls; repair the gate operator, and install a cover for the riser to eliminate the possibility of unauthorized operation and to eliminate rock accumulations in the base of the riser; repair the gate seat; inspect the total length of the outlet works, including the intake area, and perform the necessary repairs; investigate the source of seepage below the pipe at the outlet (see Section 3.1.3), and identify potential adverse effects; and place additional rock riprap at the outlet to minimize downcutting and lateral scour, particularly for protection during peak releases.

(3) Perform the following repairs on the spillway: enlarge the channel cross section from approximately HKM Survey Station 1+60 to the vertical drop, or Station 3+60, and revegetate the side slopes along the spillway channel for stabilization.

(4) Perform the following repairs on the embankment: replace/rearrange rock riprap on the upstream face where wave action has caused erosion or moved the rock riprap downslope, and remove the small bushes from the upstream face.

(5) Repair the erosion gully which has developed immediately upstream of the right abutment area, and modify the localized runoff system to eliminate future erosion in this area.

(6) Conduct more detailed hydrologic and hydraulic routing studies to better determine the downstream hazard and required spillway capacity and modify the project as studies indicate.

(7) Conduct and place on file a stability analysis of the dam embankment. It is recommended that this analysis be performed by a qualified geotechnical engineer and that the dam be modified as studies indicate. Also, monitor the topsoil sloughing on the downstream face for an assessment of localized stability and erosion problems.

(8) Conduct periodic inspections by qualified engineers at least once every five years to determine whether there are any deficiencies in the condition of the project, to assess the adequacy and quality of maintenance, and to evaluate methods of operation. Include an inspection of the total length of the conduit through the embankment in this program.

(9) Develop and implement a periodic maintenance plan for the dam and appurtenant structures.

Prior to performing engineering studies and remedial construction, coordinate the work with the Montana DNRC, Dam Safety Section, to insure compliance with all pertinent laws and regulations.

REFERENCES

1. U.S. Army Corps of Engineers, Office of the Chief of Engineers Report to the U.S. Congress, National Program of Inspection of Dams, Vol. 1, Appendix D, "Recommended Guidelines for Safety Inspection of Dams". Washington, D.C., Department of the Army, May 1975.

2. U.S. Geological Survey, 7-1/2 Minute Quad Maps, Hanson Reservoir, Montana, 1971, and Alkali Lake, Montana, 1971.

3. U.S. Geological Survey, White Sulphur Springs, Montana, AMS, Scale 1:250,000, 1958 with revision 1972.

4. Groff, S.L., Reconnaissance Groundwater and Geologic Studies of Western Meagher County, Montana, Montana Bureau of Mines and Geology, Special Publication 35, 1965.

5. Von Hake, C.A., Earthquake Information Bulletin, USGS, Vol. 10, No. 4, 1978.

6. National Oceanic and Atmospheric Administration, Climatological Data, Montana, National Climatic Center, Asheville, N.C.

7. National Oceanic and Atmospheric Administration, Climates of the States, Volume II, "Western States Including Alaska and Hawaii", Port Washington, N.Y., 1974.

8. U.S. Bureau of Reclamation, Design of Small Dams, 2nd. Edition, 1973, Revised Reprint, 1974.

9. Department of Planning and Economic Development, State of Montana, "Comprehensive Area-Wide Water and Sewer Plan, 1970, State of Montana, Meagher County, 1971.

10. National Weather Service, Interim All-Season Probable Maximum Precipitation Estimates, Missouri River Drainage West of the 105th Meridian, January 1, 1980.

11. National Weather Service, Hydrometeorological Report No. 43, Probable Maximum Precipitation, Northwest States, Washington, D.C., 1966.

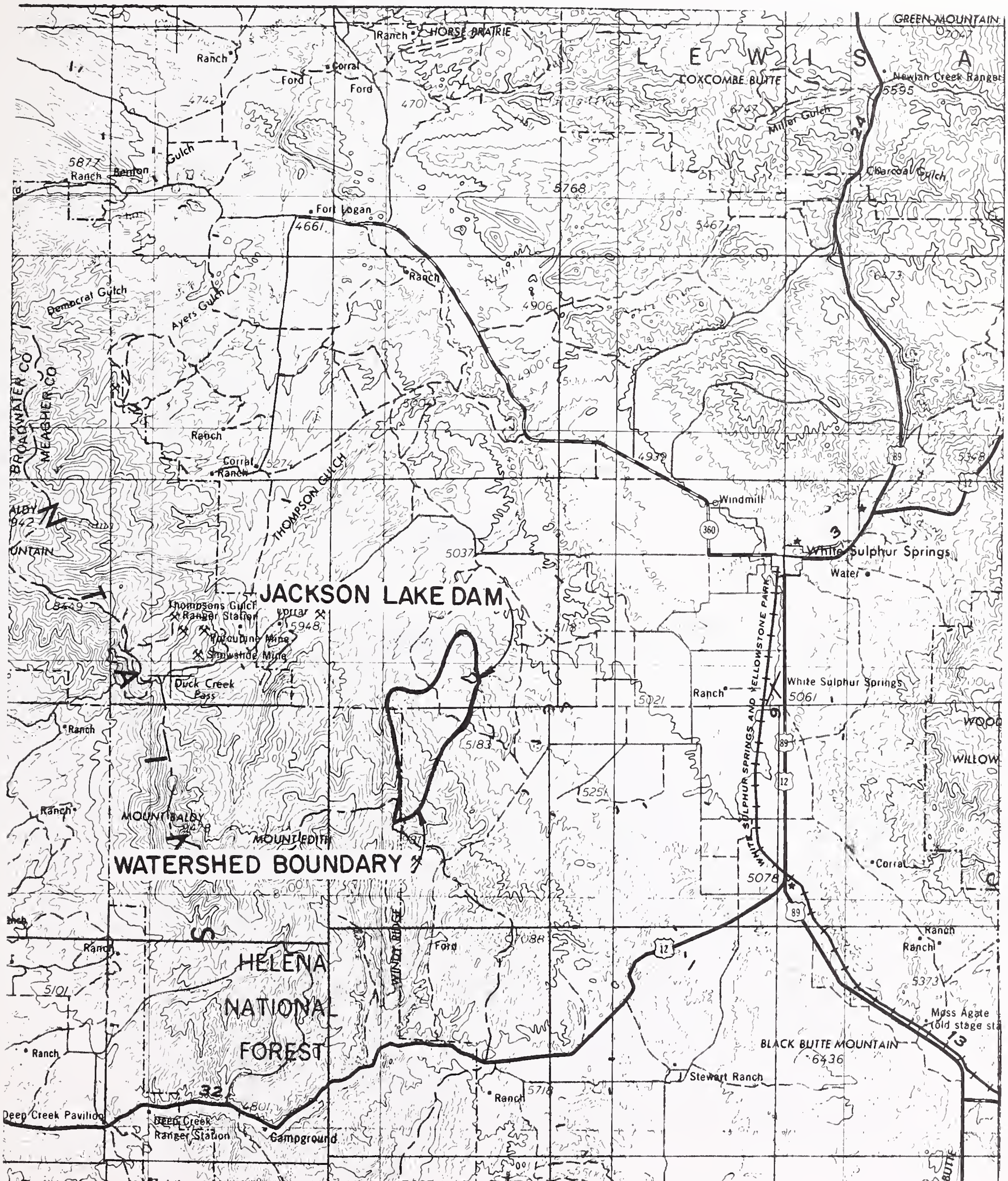
12. U.S. Soil Conservation Service, National Engineering Handbook, Section 4, "Hydrology", Washington, D.C., 1969.

13. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-1 Flood Hydrograph Package, Davis, California, September, 1978.

14. U.S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-2 Water Surface Profiles, Davis, California, October 1973.

APPENDIX A

VICINITY & WATERSHED MAP



5 0 5 MILES

SCALE

SOURCE: WHITE SULPHUR SPRINGS, MONTANA
AMS MAP, U.S.G.S.

N

APPENDIX A

VICINITY & WATERSHED MAP

JACKSON LAKE DAM

APPENDIX B

INSPECTION PHOTOS

Photo No. 1 - Damsite.
Shown is the downstream face of the dam embankment with the upstream watershed in the background.

Photo No. 2 - Spillway.
The uncontrolled earth spillway is shown looking upstream from the control towards the reservoir.

Photo No. 3 - Spillway.
The spillway channel downstream of the control is steep and deeply cut.

Photo No. 4 - Outlet Works.
The outlet pipe is a 15-inch corrugated metal pipe.

Photo No. 5 - Outlet Pipe.
The outlet pipe leaks water through a joint about 24 inches upstream from the end on the left side.

Photo No. 6 - Shown is the upstream face of the dam embankment and the 36-inch corrugated metal riser pipe.

Photo No. 7 - Dam Embankment.
Seepage is emerging along the downstream toe of the dam.

Photo No. 8 - Reservoir.
Erosion channel along the south (right) side of the reservoir has been cut due to localized runoff.

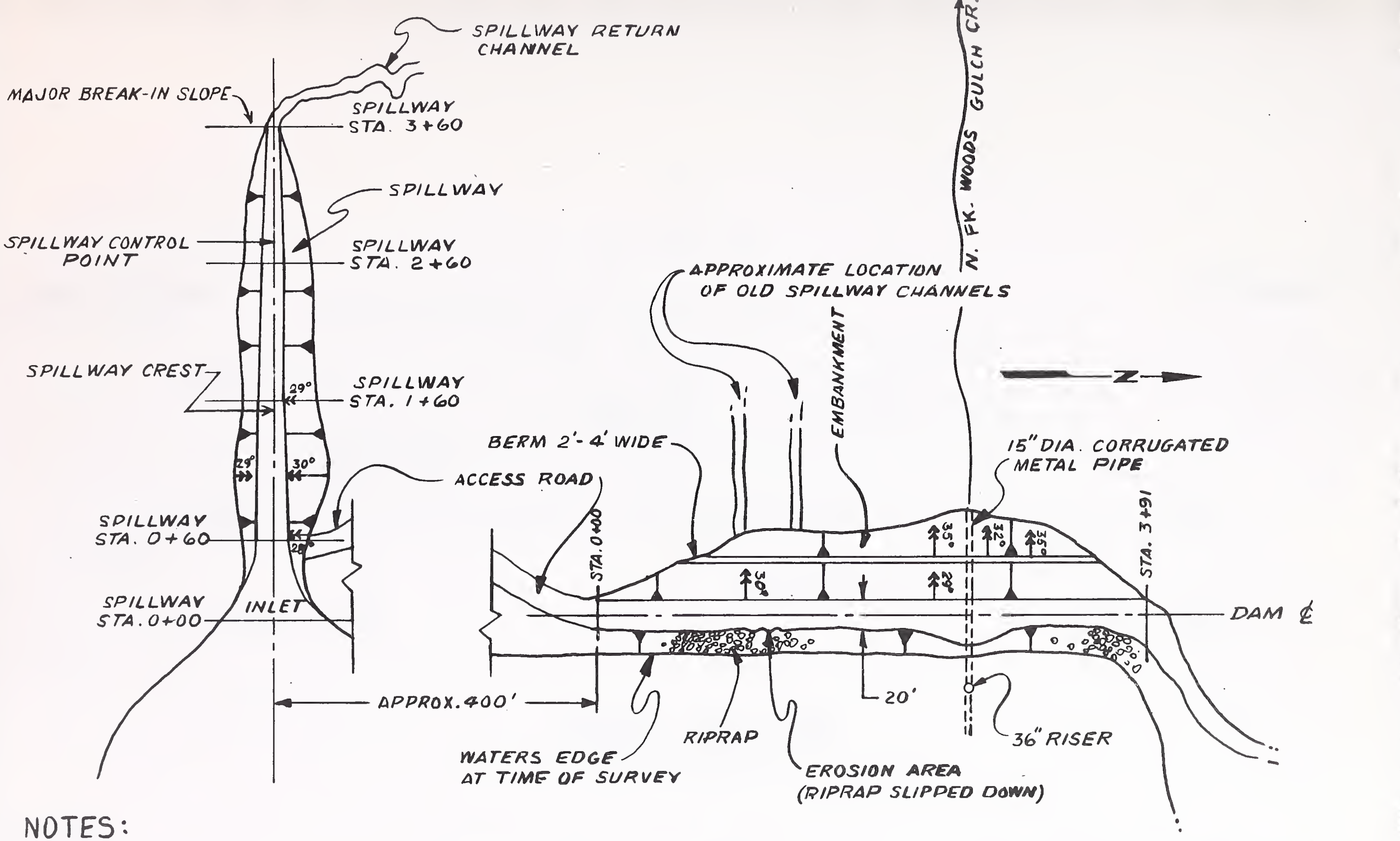
Photo No. 9 - Dam Embankment.
The riprap along the upstream face of the dam is pictured.

Photo No. 10 - Dam Embankment.
Wave action has eroded the upstream dam embankment to near vertical cuts.

APPENDIX C

PROJECT DRAWINGS

Exhibit C1	Plan View & Embankment Slopes
Exhibit C2	Embankment Cross Section
Exhibit C3	Dam Crest Profile
Exhibit C4	Spillway Profile & Cross Sections



NOTES:

1. - ALL STATIONS AND SLOPES ARE FROM FIELD SURVEY PERFORMED ON 6/25/80

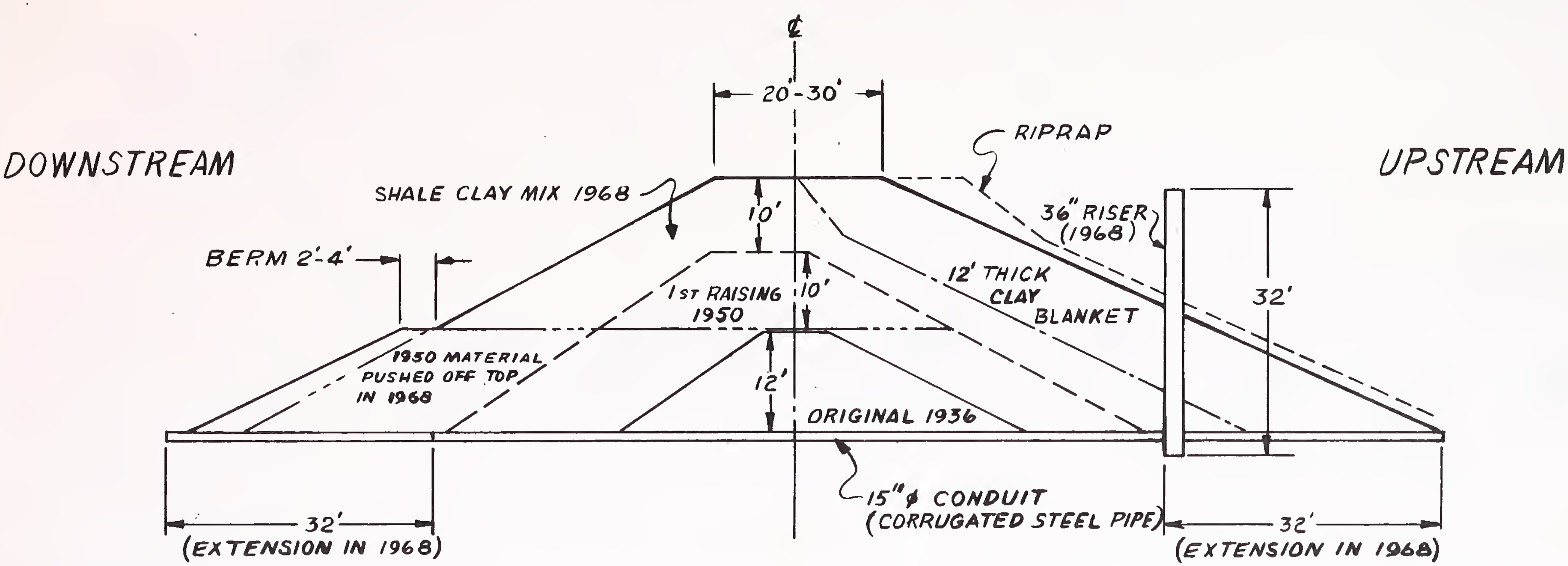
PLAN VIEW

APPROXIMATE SCALE: 1" = 100'

EXHIBIT C1

PLAN VIEW AND EMBANKMENT SLOPES

JACKSON LAKE DAM



CROSS SECTION

NOT TO SCALE

NOTES:

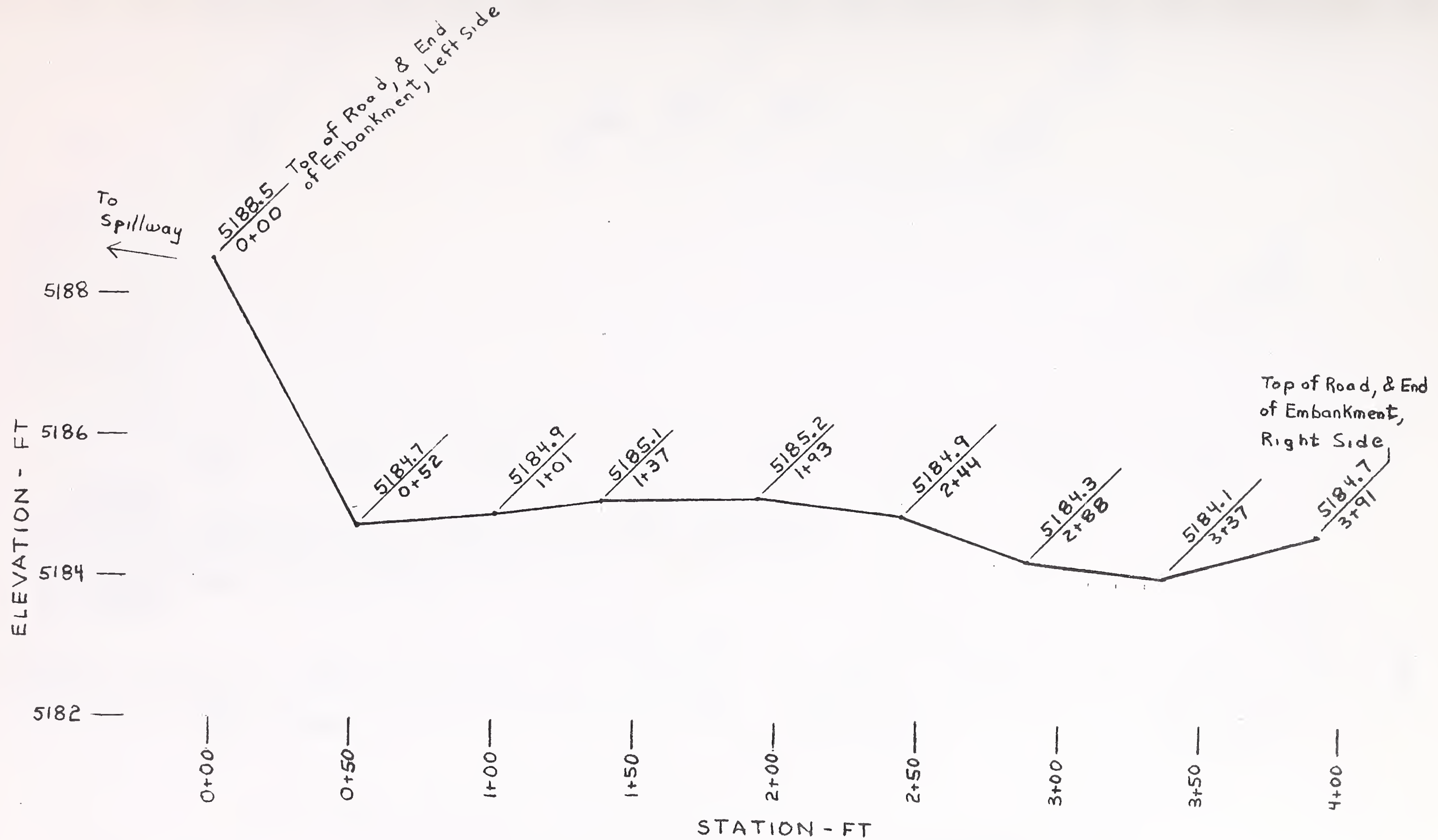
1.- ALL EMBANKMENT DIMENSIONS ARE APPROXIMATE.

2.- DATES AND CONFIGURATIONS WERE OBTAINED FROM VERBAL DESCRIPTIONS GIVEN BY THE OWNER.

EXHIBIT C2

EMBANKMENT CROSS SECTION VIEW

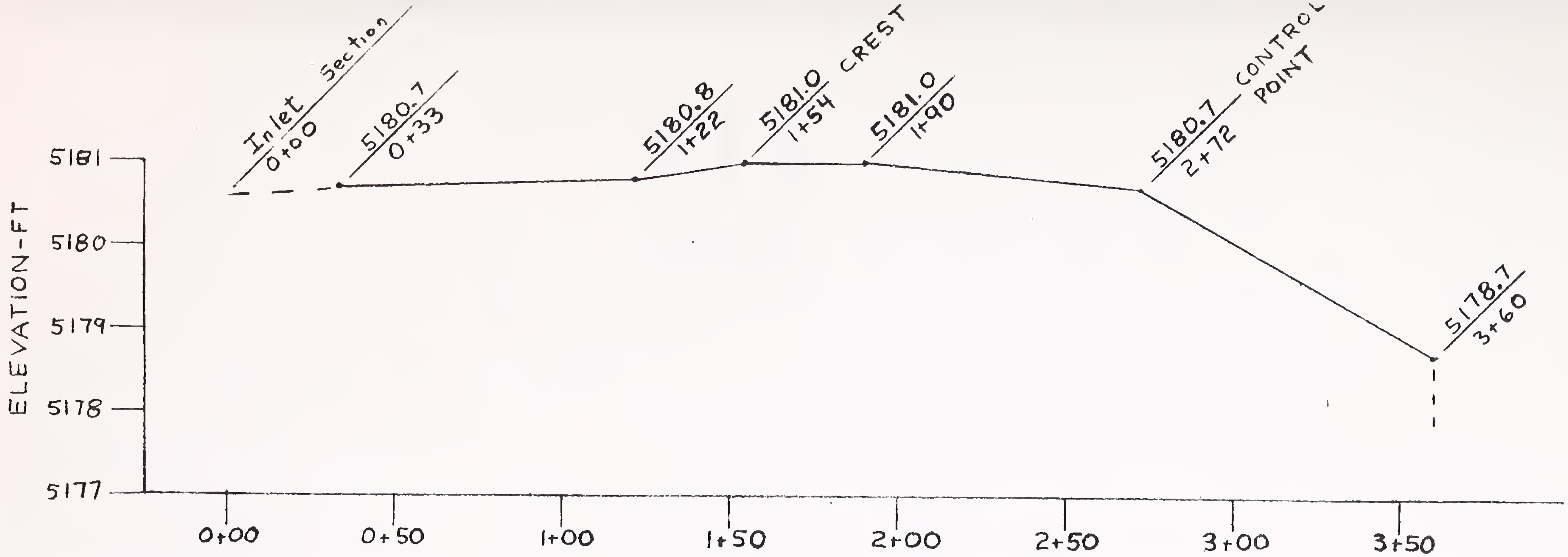
JACKSON LAKE DAM



NOTES

1. Elevations based on spillway crest = El. 5181.0 FT (See note at end of Pertinent Data Summary in the text.)
2. Elevations and stations from HKM Associates survey performed on 6/25/80

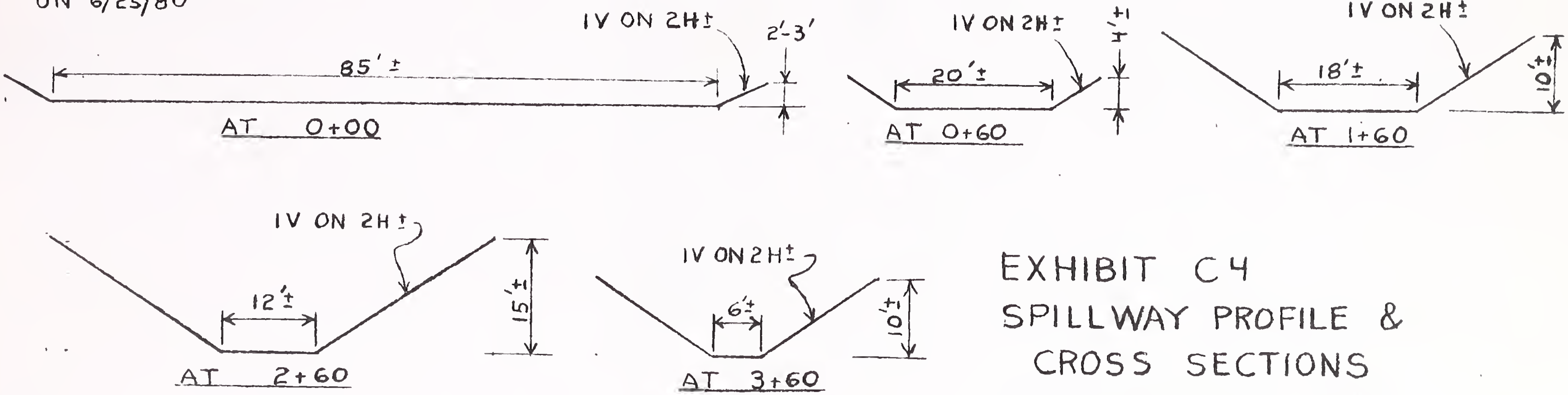
EXHIBIT C3
DAM CREST PROFILE
JACKSON LAKE DAM



SPILLWAY PROFILE
Scale: 1" = 50' H, 1" = 2' V

NOTES:

1. ELEVATIONS BASED ON CREST EL. = 5181 FT (SEE NOTE AT END OF PERTINENT DATA SUMMARY)
2. DATA SHOWN FROM FIELD SURVEY ON 6/25/80

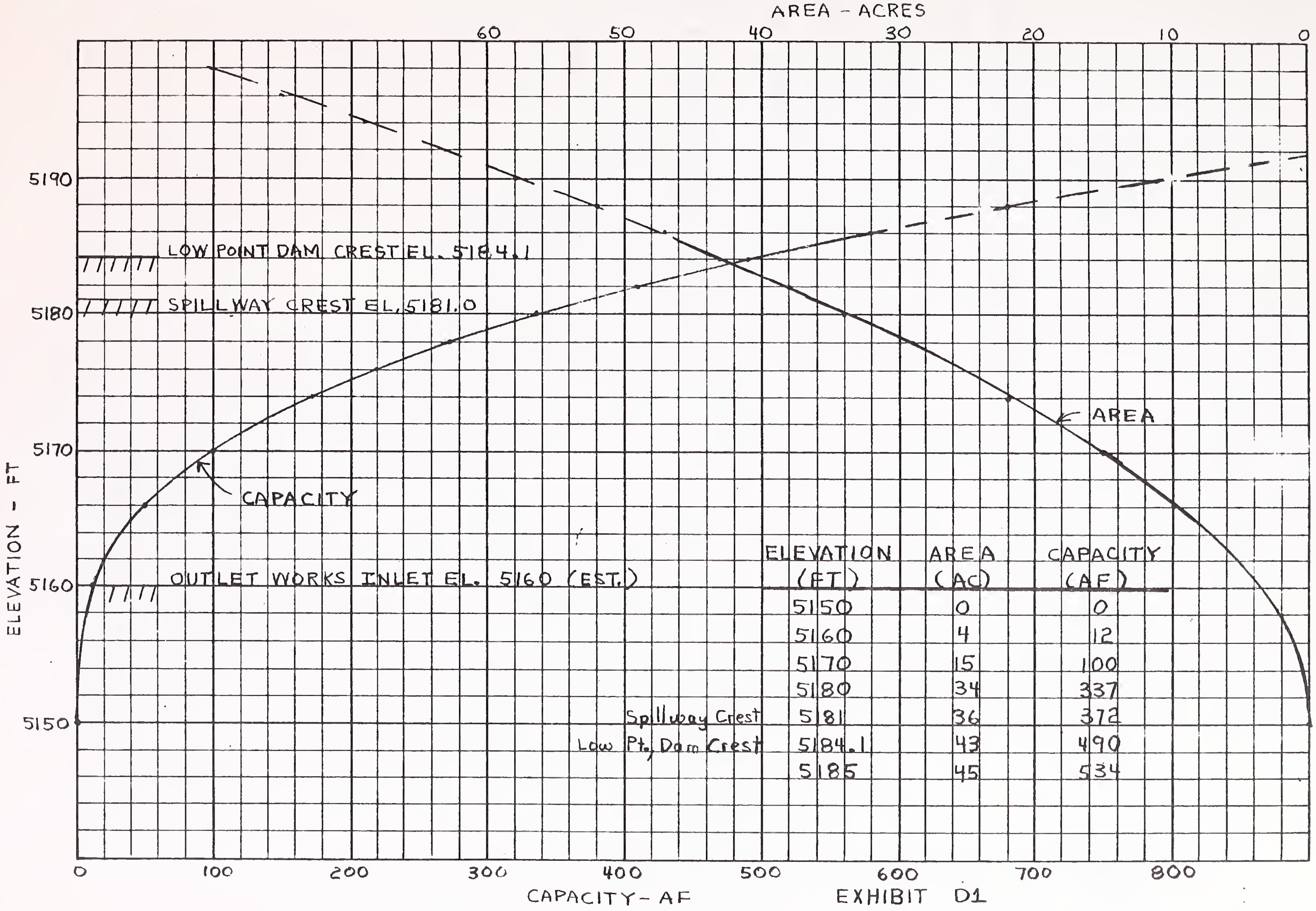


SPILLWAY CROSS SECTIONS
Scale: 1" = 10' H & V

EXHIBIT C4
SPILLWAY PROFILE & CROSS SECTIONS
JACKSON LAKE DAM

APPENDIX D

ENGINEERING DATA



	ELEVATION (FT)	AREA (AC)	CAPACITY (AF)
	5150	0	0
	5160	4	12
	5170	15	100
	5180	34	337
Spillway Crest	5181	36	372
Low Pt. Dam Crest	5184.1	43	490
	5185	45	534

EXHIBIT D1
ELEVATION-AREA-CAPACITY CURVES
JACKSON LAKE DAM

EXHIBIT D2

DISCHARGE RATING TABLE

JACKSON LAKE DAM

ELEVATION (FEET)	OUTLET WORKS DISCHARGE (CFS)		SPILLWAY DISCHARGE (CFS)
	Calculated	Rounded	
5160 (Outlet Works, Inlet, Est.)	-	0	-
5165	-	*	-
5170	10.5	11	-
5175	12.0	12	-
5180	13.3	13	-
5181 (Spillway Crest)	13.6	14	0
5182	13.8	14	25
5184.1 (Low Point Dam Crest)	14.3	14	210

*Probable non-pressure flow

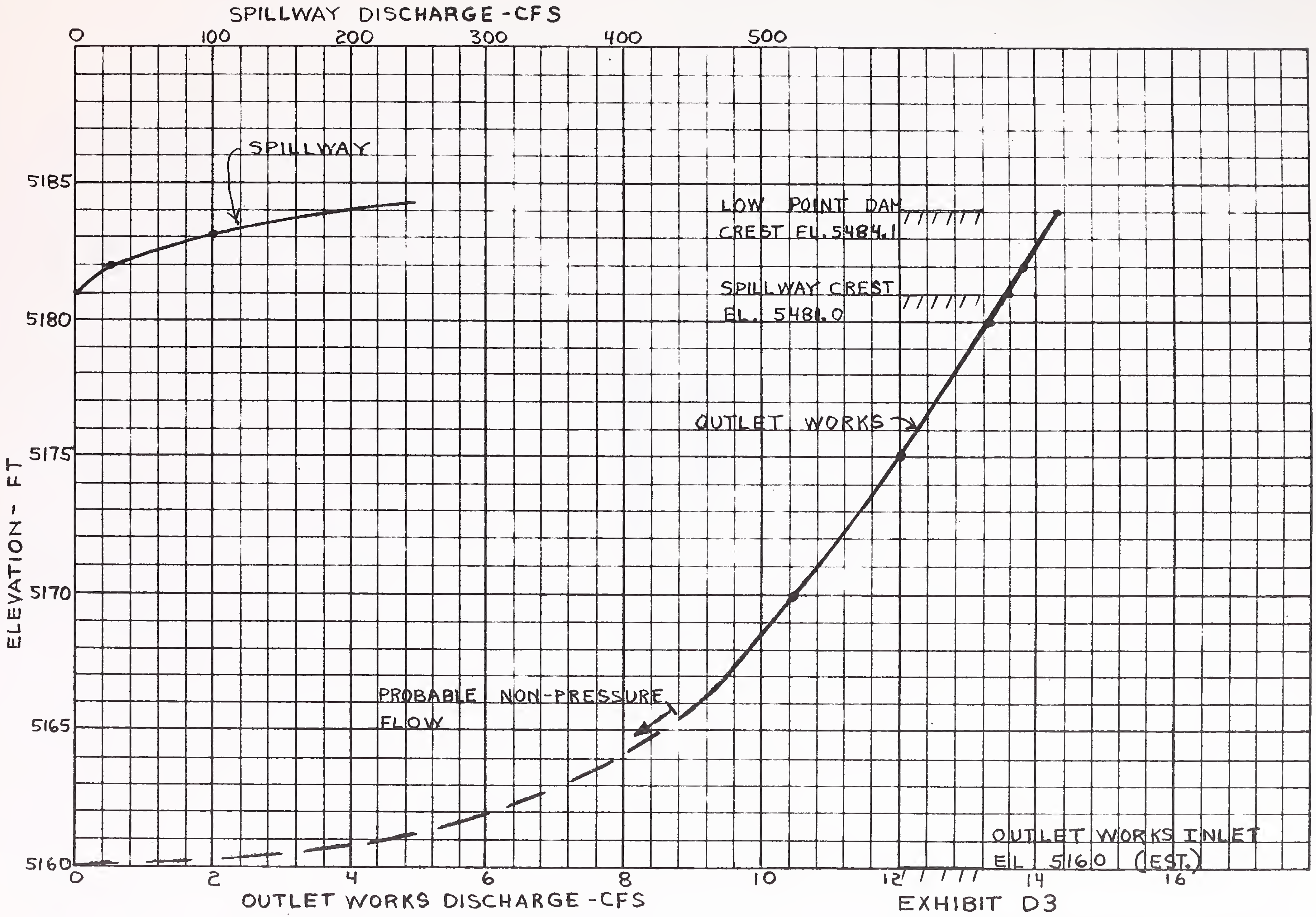


EXHIBIT D3
DISCHARGE RATING CURVES
JACKSON LAKE DAM

APPENDIX E

CORRESPONDENCE

DEPARTMENT OF NATURAL RESOURCES
AND CONSERVATION
WATER RESOURCES DIVISION

THOMAS L. JUDGE, GOVERNOR
32 SOUTH EWING

STATE OF MONTANA

(406) 449-2872
HELENA, MONTANA 59601

January 22, 1981

Ralph Morrison
Department of the Army
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, Washington 98124

Dear Mr. Morrison:

The Department of Natural Resources and Conservation has reviewed the final draft report on the Jackson Reservoir Dam (MT-53). We concur with the findings and recommendations in the report and feel that the report satisfies the criteria for the Phase I investigation. Our comments have been discussed with your staff and we understand that they will be incorporated into the final report.

Thank you for the opportunity to review and comment on the final report for this project.

Sincerely,

Richard L. Bondy

Richard L. Bondy, P.E.
Chief, Engineering Bureau
(406) 449-2864

RB:LT:lj

United States
Department of
Agriculture

Soil
Conservation
Service

P.O. Box 970
Bozeman, MT
59715

January 8, 1981

Sidney Knutson, P.E.
Assistant Chief
Engineering Division
Seattle District, Corps of Engineers
P.O. Box C-3755
Seattle, WA 98124

Dear Mr. Knutson:

Thank you for the opportunity to review the final draft report on Jackson Lake Dam (MT-53).

Our comments relating to specific report statements are:

Page viii, line 2: The spillway is not inadequate compared to SCS design criteria but rather it is inadequate compared to the guidelines. We suggest the sentence be changed to read "The project, therefore, has an inadequate spillway that does not conform to the guidelines."

Page 11, line 9: Indicate that the shale and clay layers were mixed together as stated in page 26, line 12.

General Comments:

We urge that a breach flood routing be made to determine the actual downstream hazard classification. The proposed Spillway Design Flood of 24,720 cfs is not a realistic level of protection for this watershed and the downstream conditions.

We do not agree with the apparent meteorologic and hydrologic conditions used to develop the probable maximum flood. PMP reduction factors were not likely considered and the hydrologic conditions used were not given.

The conditions attempt to eliminate the element of risk to a degree that we feel is not practical or reasonable. Despite the climatic differences, the Omaha District appears to be imposing much more reasonable hydrologic conditions than is the Seattle District. We suggest that a common degree of risk (probability) be applied by the COE nationwide.

The meteorology, hydrology, and hazard classification withstanding, we feel the report is an accurate statement on the dam and its condition.

Sincerely,

Van K Haderlie

Van K Haderlie
State Conservationist

cc:
Ray Smith, Acting State Conservation Engineer, SCS, Bozeman
Dave Jones, Environmental Engineer, SCS, Bozeman